

# InGaN Multi-Quantum Well Laser Diodes Grown by Low Pressure Multi-Wafer MOCVD

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## Abstract

InGaN/GaN multi-quantum well (MQW) laser diodes (LDs) were grown using MOCVD on epitaxially laterally over-grown (ELOG) GaN/c-plane sapphire substrate. The threshold current was 45 mA for a ridge-type LD with an area of  $2 \times 500 \mu\text{m}^2$ . The calculated threshold current density was  $4.5 \text{ kA cm}^{-2}$  and the operating voltage was 5.5 V. The lifetime of the LD was measured under an output power of 1mW in automatic power controlled mode at room temperature. The lifetime was 60 hrs.

## Introduction

Nitride semiconductor short wavelength laser diode (LD) has attracted much attention as a light source for the optical data storage. Since Nichia co. reported the pulsed lasing with InGaN MQW LD in the end of 1995,[1] a significant progress has been made in the development of blue LD[2,3,4]. Nichia co. has already demonstrated a CW blue LD of a 395 nm wavelength with lifetimes in excess of 10,000 hrs [4]. In this paper, we report the properties of InGaN/GaN MQW LD with a peak wavelength of 405 nm operated at room temperature under cw conditions.

## Experiments

The LD structure was grown on ELOG GaN using a

multi-wafer MOCVD system into which three 2" wafers can be loaded in a time. The ELOG GaN was grown on a pattern of  $4 \mu\text{m}$  window and  $10 \mu\text{m}$   $\text{SiO}_2$  mask. The pattern was formed on  $4 \mu\text{m}$  GaN film/c-plane sapphire substrate. In order to form ridge-type LDs the structure was etched using chemically assisted ion beam etching (CAIBE). The area of the ridge LD was  $2 \times 500 \mu\text{m}^2$ . Laser facets were formed by CAIBE, and 2 pairs of quarter-wave  $\text{TiO}_2/\text{SiO}_2$  dielectric multilayers were employed on the facet surface.

## Results

The electrical characteristics of the LDs were measured under a direct current. Figure 1 shows L-I-V characteristics of one of the LDs with a ridge area of  $2 \mu\text{m} \times 500 \mu\text{m}$ . Threshold current was found to be 45 mA, corresponding to a threshold current density of  $4.5 \text{ kA cm}^{-2}$ . The operating voltage of the device at the threshold current was 5.5 V.

Figure 2 shows the results of a lifetime test of room temperature cw operated LDs in automatic power controlled mode. The operating current is shown as a function of time under a constant output power of 1 mW per facet. The operating current gradually increases up to 72 mA due to the increase in the threshold current and sharply increases after 60 hrs,

leading to the breakdown. The operating current of 72 mA from which the catastrophic increase of the current started is somewhat lower than what other group have reported.[2] Further investigation is in progress to understand the early failure of the LDs.

## Conclusion

We demonstrated the room temperature cw lasing of InGaN/GaN MQW blue LD grown by MOCVD. Threshold current density was found to be  $4.5 \text{ kA cm}^{-2}$  for a ridge-geometry LD with an area of  $2 \text{ } \mu\text{m} \times 500 \text{ } \mu\text{m}$ . The operating voltage at this threshold current was 5.5 V. The measured lifetime in automatic power controlled mode under an output power of 1mW was 60 hrs.

## References

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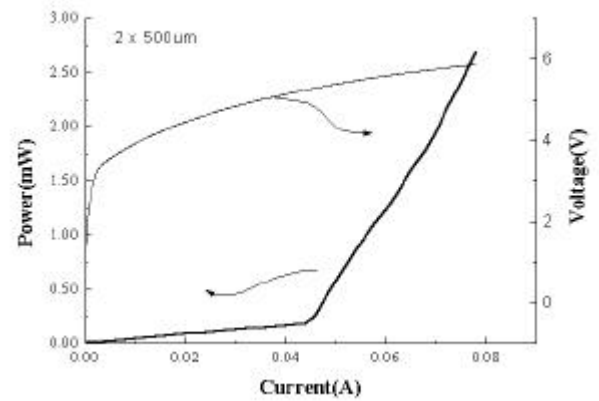


Fig. 1 L-I-V Characteristic of LD

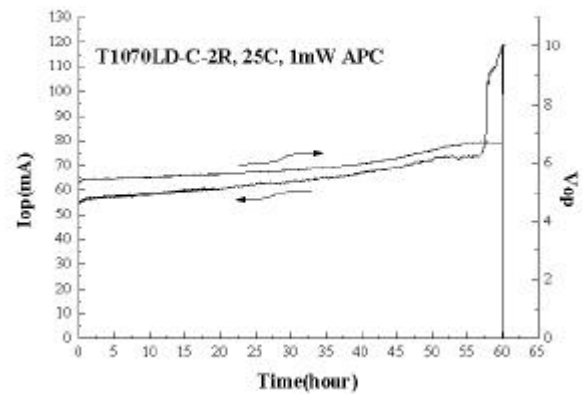


Fig. 2 Lifetime test of LD